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# Utilization of NDMI Method in Landsat 8 Satellite Imagery for Analysis of Multi-Hazard Susceptibility

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**ABSTRACT**

Liquefaction and landslide can occur during earthquakes caused by changes in soil saturation levels so that the soil loses strength due to loss of tension between grains. One of the determinations of soil moisture data using satellite imagery analysis is Landsat. Landsat has provided moderate, global, synoptic spatial resolution and repeated earth's soil surface coverage. This paper discusses the multi-hazard susceptibility using Landsat-8 satellite imagery with a combination of NDMI (Normalized Difference Moisture Index) ratio bands in Sunurraya Village and Simpang Saga Village, South OKU Regency, South Sumatra. The combination of NDMI bands determines the spread of soil saturation levels and differences in moisture in vegetation conditions. Other supporting data are soil's physical properties, including water content, density, hydrometer analysis, and Atterberg limits analysis. Overlay of NDMI data analysis and soil test analysis shows the level of liquidation insecurity in the research area on a regional and local scale.

**Keywords:** NDMI; Landslide; Liquefaction; Landsat 8; Mitigation

## 1. INTRODUCTION

The utilization of aerial and satellite imagery in remote sensing to determine the conditions on the earth's surface is one of the stages in research that acts as the main parameter. Remote sensing used in this study uses Landsat 8. Landsat satellite has been recording earth surface data since 1972 by the United States Geological Survey (USGS). Landsat data is widely relied upon in various remote sensing studies, one of which is to observe changes in changes that occur at ground level by observing surface reflectance values [1]. A remote sensing method that utilizes Landsat 8 imagery with the Normalized Difference Moisture Index (NDMI) band ratio method, the NDMI band ratio can identify the soil surface moisture index so that it can be interpreted in the texture and depth of the soil related to the level of vulnerability of an avalanche or liquefaction. One band ratio that can be used in identifying land surfaces is the Normalized Difference Moisture Index (NDMI) which uses a combination of band 5, also known as Near Infrared (NIR), and band 6, also known as Shortwave Infrared (SWIR) [2].

Landslide is a transfer of material that forms slopes, i.e., rocks, robbery materials, soil, or a combination of these materials that move down or out of the slope. For example, a landslide can occur if water seeps into the soil and the water penetrates until the watertight soil acts as a field of derailment, then the soil becomes slippery, and the weathering soil on it will move following the slope and out of the slope. Meanwhile, liquefaction is a symptom of sand release mixed with earthquakes where the trigger force exceeds the local lithological force to withstand shocks. This can lead to several events such as rapid decline, tilt or partial decrease (differential completion), and decreased well water level sustained by non-cohesive materials. On the other hand, liquefaction can result in significant damage to the environment, buildings, road distortion, or damage to buried infrastructure [3]. Controlling factors that can result in liquefaction include soil moisture, slope, rock type, soil type or texture, land use, etc.

Some researchers have used the NDMI band ratio in Landsat 8 imagery to identify soil and rock surface moisture and interpret soil texture, given the correlation between soil moisture levels and soil textures [1]. For example, Yang et al. and Abrol et al. in Jimmy [1*****/=-*-r] say that there is a correlation that is directly proportional when soil moisture is high then the content of clay and silt grains is also high, conversely when soil with the content of dominant sand grains has a lower humidity level.

This study uses Landsat 8 imagery with a Normalized Difference Moisture Index (NDMI) band ratio, in which this study aims to determine whether there is a potential for landslides and liquefaction in the study area and whether this method is effective in determining the potential for landslides and liquefaction in the study area. The soil properties parameters used by soil test data such as soil water content analysis, soil type weight, hydrometer analysis, Atterberg limits analysis, and record of earthquake events in research areas where the data will be processed using ranking methods.

## 2. METHOD

The study was conducted using secondary data and supported by field data collection. The data used in this study are 7 parameters selected based on aspects that can affect the occurrence of landslides and liquefaction in the study area; the 7 parameters are NDMI band ratio combination of the research area, Earthquake information data, Rainfall data, Earth movement vulnerability map, Morphological information, Slope map, and Soil test results. Secondary data collected in the form of Landsat 8 Level 1 satellite imagery with path /row 124/63 silverization from 2014 - 2017, vulnerability map of the land movement of the research area that can be seen from the Central Gallery of Volcanology and Geological Hazard Mitigation (PVMBG), rainfall data obtained from the Central Statistics Agency (BPS) of South OKU Regency, information about earthquakes that have occurred in the research area, and data related to contour data or DEM (Digital Elevation Model) imagery such as topography, morphological interpretation, and slope maps. Meanwhile, field data supporting this study are soil samples taken from two locations, namely Simpang Saga Village and Sunurraya Village, which will later be conducted soil tests, including groundwater tests, soil type, weight, hydrometer analysis, and Atterberg limits analysis.

Once all the necessary data is in place, it will be given parameter weighting using the ranking method. The purpose of parameter weighting is to express how much influence one parameter has on other parameters. Parameters or data that have been collected will be compiled based on ranking. Self-determination is subjective and strongly influenced by the perception of decision-making. In this study, the ranking determination is based on the main parameters to supporting parameters; essential parameters will be given a value of 1, essential parameters are given a value of 2 until less important parameters are given a value of 7. If the ranking has been determined, then the next step is to determine the weight of each parameter, namely by using the approach of the number of rankings calculated based on Eq. 1 below.

$$Wj = (n - rj + 1) / \sum(n - rp + 1) \qquad \text{Eq.1}$$

Where wj is the normal parameter for a parameter to j (j =1,2... n), n is the number of parameters under review, p is the parameter (p=1,2... n), and rj is the ranking positions of a parameter. Each existing parameter will be weighted (n - rj + 1) and then normalized with ∑(n - rp + 1).

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The combination of NDMI band ratios obtained from the composition of band five is also referred to as Near Infrared (NIR), which has a function to emphasize biomass content and coastline, and band 6 or Short-wave Infrared (SWIR) 1 where this band can distinguish groundwater content and vegetation [4]. Both band compositions are calculated using Eq. 2 below.

$$NDMI = \frac{NIR - SWIR\ 1}{NIR - SWIR\ 1} \qquad \text{(Eq. 2)}$$

The process of combining and calculating the NDMI ratio band is carried out there is an Arcmap application and obtained a range of values of NDMI results is dry very wet (**Figure 1**).

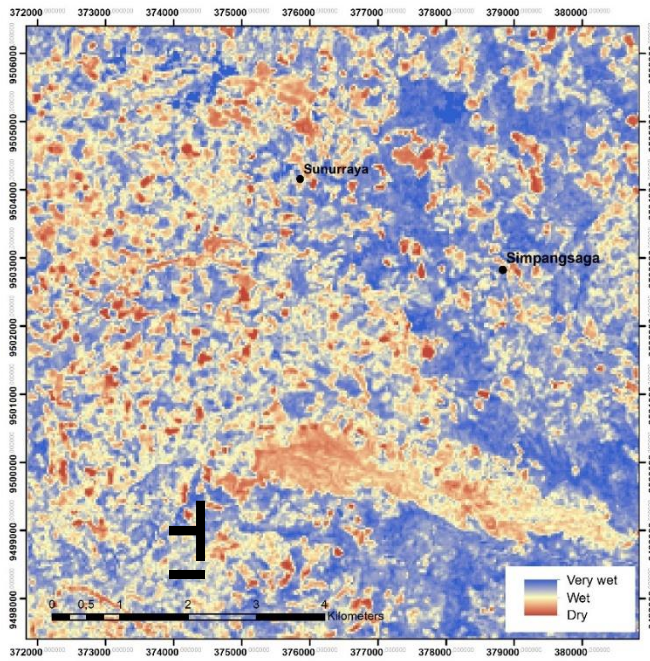


**Figure 1** Result of band ratio NDMI

From the results of observations and matching in some regions, red is an area where the level of moisture of the soil surface is dry, areas with cream color characterize areas where soil moisture is wet, while blue areas are areas where the level of soil moisture is very wet. The research location is in Sunurraya Village and Simpang Saga Village. It can be seen from **Figure 1** that Sunurraya Village has a moisture barrier from dry to wet, while in Simpang Saga Village, the level of humidity is wet to very wet. On the other hand, judgment from the slope of the slopes of the research area, including gently sloping to sloping based on the classification of Widyatmanti (2016) [5], which can be seen in **Figure 2**. The morphological appearance of the research area is can be seen in **Figure 3.**

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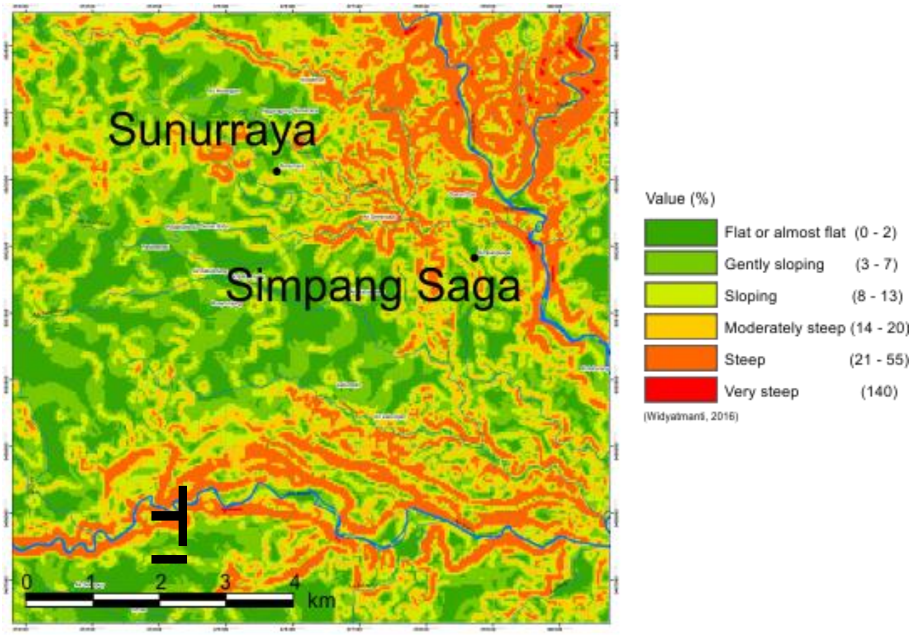


**Figure 2** Map of slope in the research area

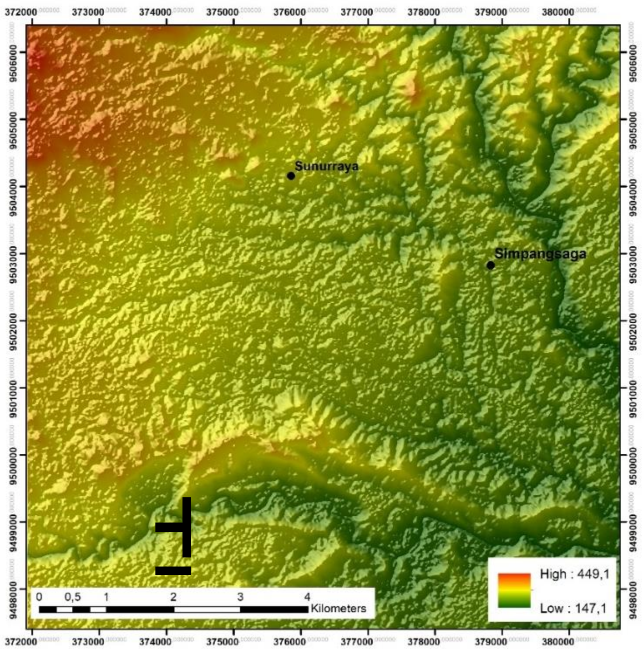


**Figure 3**. Morphological appearance of the research area

On the map of the zone of the vulnerability of land movement that can be accessed in the PVMBG Map, the research area is included in 2 zones (**Figure 4**), namely Simpang Saga Village, including into the zone of vulnerability Low ground movement, which in general this zone rarely occurs ground movement if there is interference on the slope. If there is old soil movement, the slope has been steadily returned. However, small-dimensional ground movements may occur, especially on river valley cliffs. While Sunurraya Village is a Zone of vulnerability of medium land movement, there can be land movement in this zone, especially in areas bordering river valleys, gawir, road cliffs, or if the slopes are disturbed. Old soil movements can be re-active due to high rainfall and intense erosion. Earthquakes can also

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trigger ground movement in this research area. The record of earthquakes that hit the research area is a magnitude 5.0 earthquake that shook the Southwest Of Ogan Komering Ulu Regency (OKU) Parent, South Sumatra Province, whose earthquake shock can be felt up to the research area. Based on data obtained from the BMKG (Meteorology, Climatology, and Geophysics Agency) website, the earthquake occurred on Sunday (08/20/2017) centered in the Mount Megang Area. The earthquake is estimated to be located in Mendingin Village of Ulu Ogan Subdistrict, OKU Regency bordering Kisam Tinggi District and Muaradua Kisam, South OKU Regency.

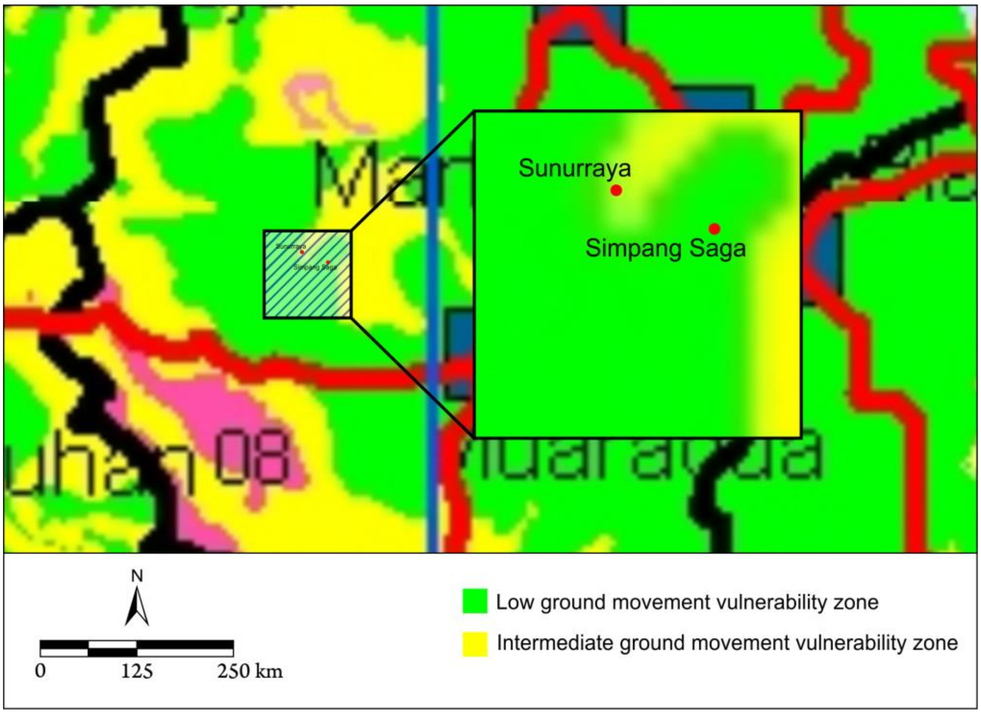


**Figure 4** Map of the vulnerability zone of the land movement of the research area

Rainfall data based on BPS South OKU Regency in 2020, the highest rainfall in the research area was in April and March, which amounted to 396.5 mm3 and 367.9 mm3, while the average rainfall of South OKU Regency in 2020 was 219.05 mm3. So it can be concluded that the research area is included in areas with high rainfall levels. The last parameter used in this study is the parameters of the soil test results taken directly from the research site. Soil tests conducted in this study include groundwater content tests, soil type weight, hydrometer analysis, and Atterberg limits analysis conducted in the laboratory. The Sunurraya Village soil test results obtained that the classification of soil in the form of Elastic Silt (MH) while in Simpang Saga Village in the form of Sandy Fat Clay (CH), which is inorganic clay with high plasticity.

## 3. RESULTS AND DISCUSSION

After all the data has been obtained, the results are then the ranking determination (**Table 1**). Determination in this study is done by looking from the main parameters to the supporting parameters. The calculation results with the number of rankings is can be seen in **Table 2**.

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**Table 1** Ranking parameter

| **No** | **Parameter** | **Ranking** |
|---|---|---|
| 1 | NDMI band ratio combination | 1 |
| 2 | Earthquake information data | 4 |
| 3 | Rainfall data | 3 |
| 4 | Earth movement vulnerability map | 2 |
| 5 | Morphological information | 6 |
| 6 | Slope map | 5 |
| 7 | Soil test results | 7 |

After the ranking of the parameters is obtained, calculations are carried out for the determination of the weight of each parameter using Eq 1, as follows:wj = (n – rj + 1) / ∑(n – rp + 1)
w1 = (7 – 1 + 1) / {(7 – 7 + 1) + (7 – 6 + 1) + (7 – 5 + 1) + (7 – 4 + 1) + (7 – 3 + 1) + (7 – 2 + 1) + ( 7 – 1 + 1)
w1 = 7/(1+2+3+4+5+6+7)
w1 = 7/28 = 0.25

Calculations are calculated in rank 2 - 7 in the same way as above, so that the following results are obtained: w2 = 6/28 ≅ 0.21
w3 = 5/28 ≅ 0.18
w4 = 4/28 ≅ 0.14
w5 = 3/28 ≅ 0.10
w6 = 2/28 ≅ 0.07
w7 = 1/28 ≅ 0.04

**Table 2.** Calculation results with the number of rankings

| **No** | **Parameter** | **Ranking** | **Weight (n – rj + 1)** | **No (wj)** |
|---|---|---|---|---|
| 1 | NDMI band ratio combination | 1 | 7 | 0.25 |
| 2 | Earthquake information data | 4 | 4 | 0.14 |
| 3 | Rainfall data | 3 | 5 | 0.18 |
| 4 | Earth movement vulnerability map | 2 | 6 | 0.21 |
| 5 | Morphological information | 6 | 2 | 0.07 |
| 6 | Slope map | 5 | 3 | 0.10 |
| 7 | Soil test results | 7 | 1 | 0.03 |

The analysis results using the NDMI band ratio showed that the soil of the research area is wet to very wet. The support from a map of the vulnerability zone of land movement and one of the research sites are also included in the intermediate zone of soil movement vulnerability. It shows the potential for landslides and/or liquefaction in the research area. However, this method may still not be accurate in determining the potential for landslides and liquefaction because the method used in ranking determination there is no specific benchmark. Therefore, soil tests are carried out more dominantly for the analysis of landslide potential So

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that special soil tests are needed to analyze the potential for liquefaction and the need for outputs such as landslide potential zone maps and liquefaction in research areas so that in adaptation and mitigation of multi-disasters can be done optimally.

## 4. CONCLUSION

The use of NDMI band ratio with ranking methods in the analysis of landslide and liquefaction potential is an alternative method that can be used in disaster mitigation adaptation. This method is suitable for use on regional scales with broad scales, extreme topography, and difficult access. In addition, the supporting data, namely soil tests on soil samples taken at the research site, can improve the analysis's accuracy. Adaptation and mitigation of multi-disasters need to be done to avoid areas with the potential for landslides or liquefaction.

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